THE

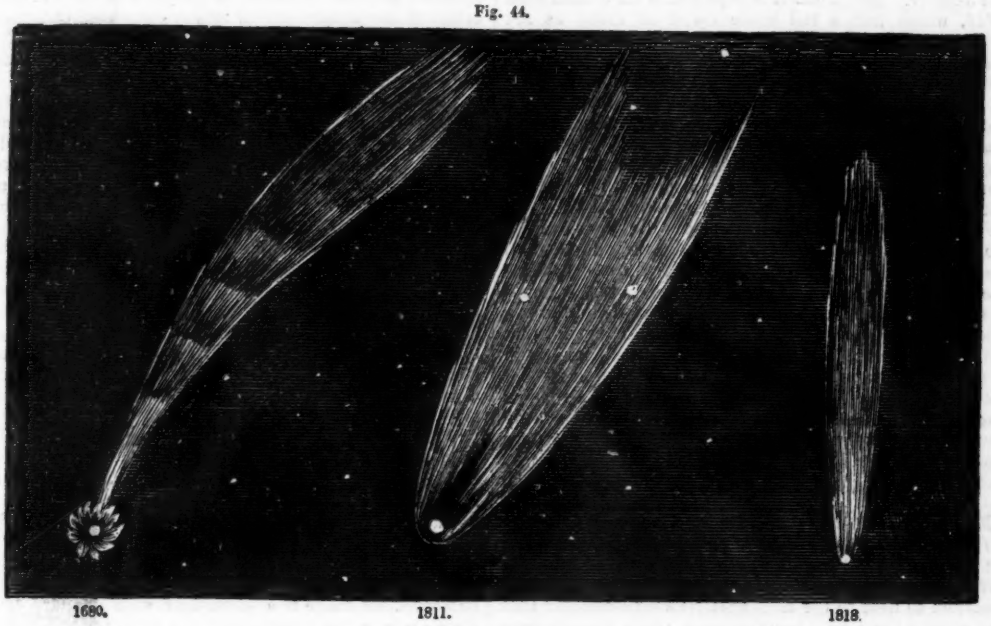
Saturday Magazine.

Nº 438. SUPPLEMENT, APRIL, 1839 { PRICE ONE PENNY.

POPULAR ASTRONOMY. PART VI.

(CONCLUDED.)

Fig. 44.



1680. 1811. 1818.

THE COMETS.

COMETS.

..... Amid the radiant orbs,
That more than deck, that animate the sky,
The life-infusing suns of other worlds;
Lo! from the dread immensity of space
Returning, with accelerated course,
The rushing Comet to the Sun descends;
And as he sinks below the shading earth,
With awful train projected o'er the heavens,
The guilty nations tremble. But, above
Those superstitious horrors that enslave
The fond sequacious herd, to mystic faith
And blind amazement prone, the enlightened few,
Whose godlike minds philosophy exalts,
The glorious stranger hail. They feel a joy
Divinely great; they in their powers exult,
That wondrous force of thought, which mounting spurns
This dusky spot, and measures all the sky;
While, from his far excursion through the wilds
Of barren ether, faithful to his time,
They see the blazing wonder rise anew,
In seeming terror clad, but kindly bent
To work the will of all-sustaining love:
From his huge vapoury train perhaps to shake
Reviving moisture on the numerous orbs,
Through which his long ellipsis winds; perhaps
To lend new fuel to declining suns,
To light up worlds, and feed th' eternal fire.—THOMSON.

THERE are but few objects in creation, which excite more wonder and interest than those comets which are accompanied by long trains, or tails, of luminous ethereal matter. In the early ages the most extravagant superstition was connected with the appearances of these visiters: whole nations seemed to feel as if they were under a terrible infliction from heaven; and an indescribable awe, which is a general attendant on ill-understood or misunderstood phenomena, prevailed on the subject. Though this feeling has now in great measure passed away, they are still objects of wonder to the uninstructed; and even those who are best informed on the subject, have little better than conjecture to offer respecting them.

The principal reasons why comets do not admit of being considered as part of the solar system in the same rank as the planets, is that they cannot be traced through their orbits with that certainty which the planets can, and that their appearances vary so greatly at different times; it has been even doubted by some whether a comet has any solid body at all, like other members of the solar system.

If we are to believe the narrations of early writers, it would appear that comets were once seen, greatly exceeding in size those which have appeared of late years; from whence it seems that the whole tribe of comets deteriorates, as if, being of an unsubstantial nature, they were gradually wearing away in the course which they describe in space. In the year 130 B.C., a comet was seen so large that it appeared to have the same diameter as the Sun. In the year 60 B.C., a large comet was seen very distinctly near the Sun, which happened at the time to be totally eclipsed, and thereby made the comet visible. The comets which appeared in 1402 and 1532, are reported to have been bright enough to be seen in the sunshine of open day. In 1680 a comet appeared, which possessed many striking phenomena: of this comet, shown in the frontispiece, we shall speak further on. It had a *nucleus*, which is considered to be the real comet itself, and this was surrounded by an atmosphere, or luminous ring, which assumed the appearance of a *beard*, called the *coma*, (from the Latin for *hair*;) hence the word *comet*,—a *hairy* body. The coma, together with the nucleus, make up the *head*; and lastly came a long *train* or *tail*, which extended to a considerable distance across the heavens; according to some accounts as much as 80°: and this is another remarkable characteristic of modern comets, that, together with their star-like appearance, their tails have likewise diminished in extent. A comet seen in the year 371 B.C., had a tail, which extended over 60° of the celestial sphere. That which appeared in the year 1618, is said to have cast a tail of 104° in extent.

At the same time it must be observed that the tail does

not necessarily accompany a comet. Many small comets have had immense tails, and many large and bright comets have had no tails. The variety is immense; for the flock of these celestial coursers seems very large, and even countless. Hundreds have been noticed in the records of the world; and, as these are the largest and brightest seen, it is presumed that many, which were small, escaped notice. Very many have been observed of late, and their number is deemed to be illimitable; for all, which are near the earth, are not always seen, owing to their being on that part of the heavens which is above the horizon during the day.

The comets of 1585, 1682, and 1763, had no tails. Indeed, the second of these three is described as being large, bright, and flaming, with an appearance like that of the planet Jupiter. But a comet is reported to have been seen in 1744, which had a tail made up of as many as six streams of light, all extending to the distance of 30° over the dome of the heavens.

Very little is known concerning the *nature* of comets: some have asserted that stars have been seen through the nucleus or head of a comet; this, however, is doubtful, as it is more probable that the light from the star is refracted through the surrounding atmosphere of the comet. It seems a more rational conjecture that the body of the comet is opaque; but that, when it approaches so near, as some of them do, to the Sun, all the substances which are vaporizable on its surface are converted into vapour, and form an immense atmosphere round it. This atmosphere, on account of the great velocity with which the comet moves, becomes left somewhat behind, and may, perhaps, furnish an origin for the coma, or the tail. Sir Isaac Newton supposed that the tail of a comet arose from a thin vapour elicited from the comet by the heat of the Sun. Another opinion is, that comets serve the purpose of bringing back to the planets of our system the electrical matter which they constantly throw off: it must be admitted, however, that all is pure conjecture on this point. It has been urged by those who advocate the hypothesis, that the body, or nucleus of the comet is opaque, that it exhibits phases similar to those of the Moon, when viewed in different directions; but this again is denied, for some comets have been watched, when about to cross over the disk of the Sun, and no spot was discoverable upon that luminary. The comet of 1680 approached so near to the Sun, that Newton estimated that it was exposed to a heat two thousand times greater than that of red-hot iron. Newton further conjectured that comets were bodies which gradually approached nearer to the Sun, and finally fell upon it, and might thus repair the waste supposed to occur from the continual emission of light and heat from the Sun. The discovery of the elliptical orbits of comets, however, deprives this hypothesis of much of its value.

But in order to come to some definite opinion about the nature, or substance, of this class of the heavenly host, we have to state that all comets, especially those of modern observation, present a vaporous sort of substance to terrestrial gaze. Their mass becomes denser towards the centre, which appears like a stellar point; and the light, whether encircling this point as a coma, or streaming from it as a tail, seems to have, as it were, the texture of the aurora borealis, and like the latter, to allow of the appearance of the stars through its filmy substance. The more prevalent opinion then, at present, respecting the nature of these beings, is that they are of a flimsy character, and that they are gradually absorbed by the Sun when they come into his neighbourhood; whence it is, that every remarkable comet, whose re-appearance has justified the expectations of mankind, has disappointed the crowds who have sought to gaze upon the strange visiter in the skies. Its spare and attenuated aspect has made us wonder what our forefathers of old saw to fear, and to be astonished at; for if astronomers had not told us when and where to look for them, we should not be aware of their presence.

Comets have great variations in size during the time they are visible. Sometimes they appear as faint objects in the distance, but enlarge by degrees, and throw out a tail, and so increase in brightness and extent till they become lost in the light of the Sun. If, during the time of the comet's *doubling* the Sun (so to speak), it lose any of its substance, it seems usually to gain in brightness; the sun-beams seem then most chiefly to promote the splendour of the tail, until the comet, having receded far away from the Sun, disappears like a spirit of ether.

In speaking of the orbits of the various planets, we always refer them to the Earth's orbit as a standard by which their directions in the heavens can be understood; and we say that an orbit is inclined a certain number of degrees to the ecliptic, or Earth's orbit, according as the two orbits deviate much or little from coincidence with each other. Now it so happens that the orbits of all the planets deviate but a very few degrees from each other, while the orbits of the various comets which have been observed deviate from the direction of the Earth's orbit by angles of almost every amount. A right angle is the largest angle that can exist between two lines or two planes, and it is found that the orbits of the comets form almost every kind of angle with the ecliptic from 0 degree (or coincidence) to 90 degrees, or a right angle: this then is one circumstance in which comets differ greatly from the planets. Another point of difference is the *form* of their orbits; the orbits of the planets are in reality elliptical, but the ellipticity, or the eccentricity,—that is, the amount of difference between the circular and the elliptic form,—is so small, that the planetary orbits differ but very little from circles. Such, however, is not the case with the orbits of the comets; they are for the most part exceedingly long, or very eccentric, ellipses,—indeed, it was for a long time doubted whether their paths were ellipses at all, or whether they were real orbits. This we must explain. There are two curved lines called parabolas and hyperbolas, to which we may obtain a rude resemblance by considering a bee-hive turned upside down; they terminate at two ends, and do not meet again at any point so as to form an orbit. Now it is susceptible of proof, that, if two of the heavenly bodies were situated in space, and acted on each other by the attraction of gravitation, one of them might have such a velocity and direction of motion given to it, as would make it describe a circle round the other body; or that, by altering the direction and velocity, the body might be made to describe either an ellipse, a parabola, or a hyperbola: in the latter two of which cases, it would never return again to the spot from whence it set out, but would continue travelling on through space for ever, unless acted on by some of the bodies in or near its path.

The question of the orbital motions of comets is referrible to that part of mathematics which is termed the "Conic Sections." The figures obtained by these sections, or divisions, of a cone, are five. If we take a cone, usually compared for shape to a sugar-loaf with a sharp top, and divide it by a line parallel with the base, the figure obtained by this division is a *circle*. If we divide it from the top vertically downwards, the figure is a *triangle*. These two figures are, however, not taken into account in this department of science, but belong to common geometry. The third section is an *ellipse*, made by cutting the cone from side to side obliquely into two parts. The fourth figure is a *parabola*, made by dividing the cone in a direction parallel with one of its sides: and the fifth figure is the *hyperbola*, made by dividing the cone in a direction parallel with its axis, which is a line descending from the vertex, or top, to the centre of the base.

But there were also circumstances, which rendered untenable the opinion, that all comets moved either in parabolic or hyperbolic orbits. Comets appeared after certain intervals, which presented exactly the same features, as to shape, position, and distance from the sun, as some which had preceded them; and, by certain calculations, it was proved that a comet, moving with the same velocity as an observed comet, would perform a certain revolution in a certain time, and that time was found to correspond with the interval between the appearances of the same comet: this combined process of calculation and observation, was applied to several comets, and the result being successful upon certain occasions, it is now considered as proved that some comets move in elliptical orbits about the sun. When, therefore, we say, that the comet, which was visible in 1835, was the same which Halley saw a century and a half ago, we mean, that a calculation, founded on the observed motion of that comet, is found to be correctly predictive, on the supposition that the orbit of that comet is elliptical.

What is the whole number of comets circulating round the sun, we are totally ignorant: about 150 have been observed with sufficient attention to mark the rates of their motion, their obliquities to the ecliptic, and other particulars, which come under the general name of the *elements* of a comet. Out of this number, however, there are but three, whose returns, after certain periods, have been correctly predicted: so vague and unsatisfactory is the knowledge which we possess of these bodies, that only three, out of the

thousands which probably exist in space, have returned to particular spots in the heavens, at times which had been foretold. These three are named after the astronomers who calculated the periods of their return,—Halley, Encke, and Biela.

In 1531 a comet appeared, of which the velocity of motion, and other particulars, were noted: in 1607 another appeared, which presented similar features to the former: in 1682 Halley, the great astronomer, observed a comet, which presented nearly the same features as the two former Now there is an interval of about seventy-six years between these eras, and Halley thought it probable that there had not been three different comets visible in those three years, but that they were successive appearances of the same comet. On calculating the extent of its orbit, he came to the conclusion that it would complete a revolution about the sun in about seventy-six years, and he boldly predicted its return in about 1757. It did not appear in that year, but in 1759; and the retardation is considered to have been due to the action of Saturn and Jupiter upon its mass, when near those planets, whereby it was delayed in its journey as much as 618 days. This effect from Saturn and Jupiter was foretold by the French astronomer, Clairaut, who fixed the time of its coming to the *perihelion*, the *nearest* part of its path to the *sun*. The event proved his correctness, within one month. It again appeared in the autumn of 1835, forming a period of about seventy-six years from the preceding appearance. There is reason to believe that an appearance of this comet can be traced back as far as 130 years B. C.; and that it is the same comet that was seen in the years 323 and 399, when it was described as being of vast magnitude and horrible aspect. This is also supposed to be the comet which appeared in 550, 855, 930, and 1006; in which latter appearance, its nucleus is reported to have been four times as large as the planet Venus. It was seen in 1230, 1305, and 1380, and again in 1456: at this last visit it was accompanied by a tail, which extended over sixty degrees of the heavens, and gave rise to so much terror and consternation, that Pope Calixtus ordered prayers to be offered up from all parts of Christendom, for the removal of the comet and its malign influences. The Turks were engaged at this time in a successful war against Greece; and when Europe was fearing nothing less than subjugation at the hands of the victorious Turks, this comet, having a tail in the form of a Turkish sabre, was regarded by the tribes of the West as the emblem of divine vengeance. After this, its appearances and progress are regularly recorded to the present times. In the sixteenth century it is said to have displayed a fine gold colour. Halley, in 1682, describes it as being as large and bright as Jupiter, with a tail of 30°. The inclination of its orbit to the ecliptic is about 17½°. In 1835, the length of its tail to the naked eye was about 6°; with a telescope it appeared larger.

Encke's comet performs its revolution round the sun in about 1208 days. This comet had been observed in 1789, 1795, 1801, and 1805, and had presented various aspects to an observer; sometimes being accompanied by a tail, and sometimes not. When it appeared in 1818, Encke, Professor of astronomy at Berlin, determined the period of its revolution as given above, and predicted its return in 1822. It returned in that year, but was not visible in England; at Paramatta, in New South Wales, however, it was seen: it appeared again in 1825, 1828, 1832, and 1835. It was visible with a good telescope between August and December of last year.

The orbits of these comets are elongated ellipses; which may be strikingly illustrated by the orbits of Encke's and Halley's comet. When the former is nearest to the sun, it is within the orbit of Mercury; that is, nearer to the sun than any of the planets; but when it is at its *aphelion*, or greatest distance from the Sun, it nearly approaches the orbit of Jupiter, which is thirteen times as distant as Mercury is from the Sun. Hence, the *aphelion*, or *furthest part* of the comet's orbit from the *Sun*, is ten times more distant from the sun than the perihelion. Halley's comet, when in perihelion, was between Mercury and Venus; in aphelion, it is twice as far off as Uranus.

The three comets, of which we here speak, are regular members of the solar system; for they move round the Sun, as their focus, in accordance with the law of gravitation. The inclination of the orbit of Encke's comet to the plane of the ecliptic is about 13¼°; and it moves like the planets, from west to east.

Its present appearance is like that of a small round nebula, without any tail. It is rather brighter at the centre than at the edges; but still its light is so faint, that it is not seen without difficulty. It does not influence any other body of the solar system; but itself suffers some perturbations from the attractions of the planets. Hence we infer that this, like most of the other comets, is little more than a vaporous globe of matter, without any specific solidity.

This comet would be comparatively insignificant, but for the aid which it affords in establishing the undulatory theory of light. According to this theory, space is considered to be filled, apart from the atmospheres of planets, with an extremely rare medium termed *ether*, by the undulations of which light is propagated. This medium, though offering no sensible resistance to the motions of the planets, was thought to be likely, if existing, to impede, to a certain extent, the passage of so airy a thing as a comet. Accordingly Professor Encke, having calculated the return of this comet upon the consideration of the *vacuum* of space, the actual time of the comet's return differed two days from the calculated return, in consequence, as asserted, of a resisting operation upon the motion of the comet in its path. But the ultimate effect of this retarding influence was discovered in *hastening*, not in deferring, the time of the appearance of the comet! for, as the all-pervading ether caused the comet to advance somewhat more slowly, the centrifugal force of the comet was diminished, whereby the solar attraction for it was increased: so that, by being drawn gradually nearer to the Sun, the time for its completing its revolution is, in consequence, diminished. In the course of time, therefore, this comet must fall to the sun. Like reasonings have been made to apply to other comets, and also to the Earth and the other planets; in order to convey to our minds the great moral lesson, that *all things have an end.* The Psalmist thus addresses the Almighty, (Ps. cxix. 96,) "I have seen an end of all perfection: but thy commandment is exceeding broad;" implying thereby, that all created nature is bounded by limits, which, however wide, are within the grasp of the Maker of all things.

Biela's comet had been noticed in 1772 and 1806, and when it appeared in 1825, Biela, a German astronomer, of Josephstadt, calculated the period of its revolution, and predicted its return in 1832:—this prediction was fulfilled, and the period of the revolution of this comet is considered to be established at 2440 days. Its last appearance was in 1832. It is spoken of as a small, insignificant comet, without a tail, or any appearance of a nucleus. The inclination of its orbit to the ecliptic, is about 13¼°; and so near does its path approach that of the Earth at the intersection of the planes, that it is considered that, in 1832, if the Earth had been one month in advance of its annual journey, it would have passed through this comet.

These are the only comets of whose periods we have any certain knowledge. There are, however, two others whose periods have been stated; but the times are not yet arrived for testing the accuracy of the predictions. One of these comets appeared in 1264, and again in 1556—an interval of 292 years; and it is expected again in 1848. The other comet, seen in the frontispiece, was observed by Newton in 1680, and he predicted its return in 575 years: a long period must therefore elapse before the truth of this calculation, or conjecture, can be verified. The tail of this comet, which is several times noticed in history, was of such vast extent, that when the head of the comet was in the horizon, the extremity of its tail was in the zenith. This observation was made at Constantinople. Of such sights as these, well might Dr. Young say—

> Hast thou ne'er seen the comet's flaming flight?
> The illustrious stranger passing terror sheds
> On gazing nations, from his fiery train,
> Of length enormous.

A remarkable comet appeared in the year 1770, which was found to revolve in a period of about five years; but the prediction of its return was not verified, in consequence of its getting too near the satellites of Jupiter, which, though undisturbed themselves by the comet, so deranged the motions of the comet, as to thrust it from its original path, and it has never been seen again. If this be correct, it shows that the mass of the comet is spare indeed. The comet of Encke is observed to grow less as it approaches the Sun, and to amplify at its departure from the solar presence; owing, it is said, to the vaporizable matter being converted into gas.

The tail of the splendid comet of 1680, observed by Newton, 120,000,000 miles in length, was observed to issue forth from the head of the comet in two days. This tail, being opposed to the Sun, is supposed to have been caused

Fig. 45. *Nebulæ.* *Uncertain.*

MAGNITUDES OF THE STARS, FROM THE FIRST TO THE SEVENTH.

by the Sun to be emitted. The tail of the comet of 1769 was 48,000,000 miles in length, and that of 1811 was 108,000,000 miles in length.

The diameter of the body of this last was 50,000 miles. It is thought that the matter of the comets is discharged at their tails, by the agency of the Sun; and that the gravitating power of the comet is not sufficient to re-collect it.

FIXED STARS.

When I behold this goodly frame, this world
Of heaven and earth consisting, and compute
Their magnitudes, this earth, a spot, a grain,
An atom, with the firmament compared,
And all her numbered stars, that seem to roll
Spaces incomprehensible (for such
Their distance argues, and their swift return
Diurnal) merely to officiate light
Around this spacious earth, this punctual spot,
One day and night, in all their vast survey
Useless besides; reasoning I oft admire,
How nature, wise and frugal, could commit
Such disproportions, with superfluous hand,
So many nobler bodies to create,
Greater so manifold to this one use,
For ought appears, and on their orbs impose
Such restless revolution day by day
Repeated, while the sedentary earth,
That better might with far less compass move,
Served by more noble than herself, attains
Her end without least motion, and receives,
As tribute, such a sumless journey brought
Of incorporeal speed, her warmth and light;
Speed, to describe whose swiftness number fails.

THE sublimity and beauty of the starry heavens is such a common subject of remark, that we need not stop to expatiate on it; but we wish to treat of some matters connected with the stars, which have not hitherto engaged our attention.

The stars appear much more numerous at first sight than they are found to be on reckoning those which are visible: this is occasioned by the glittering and twinkling, and the apparent confusion in which they seem mingled together. They have been, as we before stated, clustered into constellations, which are known by certain names; but besides this they are divided into classes, according to their *magnitudes*, the number of recognised magnitudes visible without a telescope being seven (fig. 45); which is continued, with the aid of powerful instruments, up to the sixteenth. It is, however, necessary to remark, (and nothing can give such a striking proof of the immense distance at which they are placed from the Earth), that, although we speak of *magnitudes*, the stars have really no appreciable magnitude at all: they did not appear larger through Sir W. Herschel's telescope, which magnified 6000 times, than they do to the naked eye; but they appear *much brighter* when viewed through a telescope; sometimes too bright to be gazed upon without pain to the eye, as we are told is the case when Sirius, the brightest of the fixed stars, appears through a telescope. It is, therefore, more properly speaking, by the *brightness* that we compare different stars, and not by the magnitude. Every star appears through a telescope to be a mere point of light, without appreciable diameter; and this is one of the circumstances which have baffled all the attempts of astronomers to estimate the distances of the stars.

The fact of the impossibility of magnifying the fixed stars together with that of their affording no sensible parallax, has hitherto put it out of our power to do otherwise than surmise their distances. The only use of the telescope, with reference to the fixed stars, is to penetrate more and more into space, and bring out, as it were, still greater numbers of them; so that the quantity of them seems infinite; for they multiply and spring forth, as optical aid is increased. Hence two things are clear: first, that what we call magnitude is only apparent, being referred to the power of the eye and telescope; secondly, that it depends upon distance, size, or actual quantity of light, each, or all combined.

About 50,000 stars have been catalogued; that is, their celestial latitudes and longitudes are entered, just in the same way as the position of a place on the Earth's surface. It is observable, however, that a different mode of proceeding is here adopted from that which is employed in terrestrial measurements. We have stated that the ecliptic is the path in the heavens, in which the Earth moves round the Sun, or in which the Sun appears to move round the Earth. This circle in the heavens is the place from which celestial latitudes are measured, in the same way as the Earth's equator is the beginning of terrestrial latitude. The positions of the stars are referred to this circle by such kinds of expressions as are used with respect to places on the Earth;—that is, a star being north or south of this line, has such or such latitude. As terrestrial longitude is measured on the circle which forms the 0 or zero of latitude: so, in like manner, is celestial longitude reckoned on the ecliptic, which is the 0 or zero of celestial latitude. But a point of commencement is necessary here, as well as on the Earth's surface; and the point chosen, is the *vernal equinox*, or one of the points in which the celestial equator cuts the ecliptic:—a point which, as we have said before, is called the first point of Aries. From this point then, the longitudes of the stars are reckoned; and when the latitude is previously known, we can designate the position of any star in the heavens, by this double mode of comparing its position with regard to the ecliptic.

For some astronomical purposes, it is deemed more desirable to refer the position of a heavenly body to the celestial equator, instead of the ecliptic. The celestial equator is sometimes termed the *equinoctial*, from the circumstance that, when the Sun appears in it, the days and nights are equal all over the world; and it is a circle supposed to be formed by the extension of the Earth's equator to the concave of the heavens. The distance from the celestial equator to the pole-star, is supposed, as on the terrestrial globe, to be divided into 90°; and, according as any heavenly body is situated North or South of the equinoctial, it is said to have a North or South *declination*. The East or West position of the heavenly body, considered with reference to the equinoctial, differs from longitude as reckoned on the ecliptic, in two ways: 1st. it is called *right ascension*, and not longitude: 2nd. it is usually reckoned in hours, instead of degrees. The point from which the right ascension is reckoned, is the same as with the longitude; viz., the first point of Aries: so that if the Sun be exactly at the opposite part of the heavens from the first point of Aries, he is said to have twelve hours of right ascension; twelve hours being equivalent to 180 degrees: such a position takes place on the 21st of September, when the sun enters Libra, which is diametrically opposite to the sign Aries.

By these two methods, the position of any heavenly body whether Sun, Moon, Planet, Comet, or Fixed Star, can be determined, and described with as much exactness as the position of any place on the Earth's surface.

Besides the classification of the fixed stars into constellations, it is customary, in order to distinguish one star from another, in any one constellation, to attach letters, one to each star, by which they shall be known. The letters of the Greek alphabet are used for this purpose; and, when they are all exhausted, numerals are employed, at least for the stars of small visible magnitudes. Thus, there is a star marked γ in the constellation, called Draco, or the Dragon, near the North Pole. This star comes once every day, almost precisely into the *zenith* of London, or *immediately overhead:* this star has of late years engaged much of the attention of astronomers, with the hope of obtaining, by its means, some indications of the distance at which the stars are situated from the Earth. For this purpose, there was erected at Greenwich, about five years ago, a zenith micrometer A micrometer, as the word by its derivation implies, is an astronomical instrument for *measuring small* angular distances. The object of this instrument, which was twenty-five feet long, was to measure the angular meridian-distance from the zenith of the star γ Draconis, at different times of the year, or at different parts of the Earth's orbit, which is the same thing. A variation in this angular distance at the lapse of six months, would have proved an annual *parallax:*—but this the observers at Greenwich failed to discover, and the subject remains as it was before. If the observers had succeeded in detecting a parallax of only one second of a degree, it could have been proved by calculation that this, or any other of the fixed stars, could not

have been distant from the Earth, less than 19 billions of miles.

In order, therefore, tnat astronomers may know this star when spoken of, it is called γ *Draconis*, that is, the star in the constellation of the *Dragon*, which is marked by the Greek letter γ. Some of the stars which are distinguished for their superior brilliancy, have particular names attached to them;—such as Sirius, in the right shoulder of the constellation Orion; Rigel, in his left foot; Arcturus, &c.

The principal fixed stars, which lie within a convenient distance of the moon's path, are used for taking *Lunar distances*, in order to enable mariners to deduce their longitude. The distances of particular stars from the moon, at certain regularly recurring times, when the moon is visible, are calculated at Greenwich, and set down for some years in advance according to Greenwich time. As the motion of the moon is quicker than that of any other heavenly body as seen from the earth, these lunar distances soon change. If then a person on the ocean wishes to know his longitude, and he finds, for instance, that on such a day and hour, according to the *Nautical Almanack* such a particular star is so many degrees distant from the moon, but that this lunar distance occurs as seen from the ship, an hour sooner than the Greenwich time:—in this case, his longitude is 15° W. If the recorded distance had occured an hour later, his longitude would have been 15° E.

The stars beyond the 7th magnitude are called *telescopic* stars. Those, which are visible to the naked eye at any one time, are supposed not to exceed 2,000, notwithstanding the countless assemblage which appears to be present. This results from a sort of optical delusion, whereby the eye is disconcerted by the apparent want of order: but, with the telescope, Sir. W. Herschel computed that a small portion of the heavens, not exceeding 15° in length, by 2° in breadth, exhibited not less than 50,000 stars, from which it has been calculated that the same instrument would make visible in the whole starry sphere, not less than 75 millions of stars! The mind shrinks within itself at the contemplation of such a vast array,—and still more, when it is considered that this number is limited by the imperfection of human contrivances; for there can be no doubt, that, if our telescopes were more powerful, the number of visible stars would be greatly increased. This observation may refer to that thin gauzy band of light, which seems to surround the dome of the heavens on a clear evening, when the moon is absent. It has the name of the *Galaxy*, or *Milky-way*. By the power of modern instruments this has been shown to be a vast congregation of stars so small, or so far off, that to an observer on our Earth they present only, by their association, a dim zone of light. The elder Herschel observed about 600 stars in his telescope at the same time, and they continued as numerous for a quarter of an hour. He reckoned up in one portion of the Milky-way, about 250,000 stars.

The stars are always spoken of as being *fixed*; and if we regulate our expresions by the analogy of general movements, they are certainly fixed; but astronomers have of late years seen reason to believe that a very minute motion may be detected in some stars; that is, that a certain group of stars does not present the same relative distances between the stars of which it is formed at one time, as at another. These quantities of motion, or of difference, are, however, so inconceivably small, that they belong to the refinements of astronomy, and need not be discussed here.

But we have now to notice a very remarkable circumstance, which seems to afford evidence that the stars are luminaries like our Sun, and have planets revolving round them; that each one

> Informs a system in the boundless space,
> And fills with glory its appointed place:,

When the stars are observed with close attention by means of a good telescope, many of them are found to be *double;* that is, to consist of two smaller stars, the dark division between them being too faint to be distinguished in an ordinary observation. In some instances, this may occur from one star being almost directly behind another; and though at an immense distance off from the first, yet seeming to our vision to lie in the same line: but, in other instances, it is found that one star revolves round the other, or the two revolve round some point situated between them. Very little was known on this subject until of late years, when Sir W. Herschel, and afterwards Sir J. South and Sir J. Herschel, distinctly showed that such a revolving motion was perceptible; at one time the satellite, or smaller of the two stars, would disappear, as if it had passed round behind the other in the course of its motion, just as Jupiter or Venus is sometimes invisible to us, on account of being on the opposite side of the Sun; or the satellites of Jupiter, by passing round the body of that planet. There is a double star (see fig. 47,) in the constellation called the *Great Bear*, in which the two component stars revolve round each other in about 60 years; nearly a whole circuit has been performed since its discovery in 1781. About 3000 of these double stars have been observed, and formed into a catalogue, in which their positions, with respect to latitude and longitude, and the relative positions of the two component stars of each, are entered with great exactness, in order that future observers may have the means of comparing the different appearances of these stars at different times.

In about fifty instances the stars have been found to be *triple*, or three stars revolving about a common centre. In some few cases *four*, and even *five* stars have been detected revolving in this way; thus furnishing a further analogy to the composition and relative action of the different bodies which form our own system.

Another peculiar appearance which presents itself in the heavens are *nebulæ*, which are dim, whitish, *cloudy* patches, observable at some parts of the firmament. When examined with a powerful telescope, many of them are found to consist of clusters of very minute stars, so thickly studded together, that the light of all is combined into one faint sheet, as it were, of light, and thus presents the thinly-luminous appearance by which the nebulæ are distinguished. In other instances, however, the most powerful telescopes have been unable to separate the nebulæ into stars, or clusters of stars; but the whole maintains the same thin and milky appearance, whether seen with or without the aid of the telescope. In this latter case, it is supposed that the nebulæ are formed of clusters of stars as in the former case; but that they are so extremely distant, that the light they shed is unable to reach the eye, except in a combined form from the whole of the nebulæ taken together. Some of these nebulæ appear like a faint luminous atmosphere surrounding a star of some brilliancy. Sir W. Herschel has left descriptions of about 2000 nebulæ, which he observed at different parts of the heavens.

It is considered to be probable, that the fixed stars are SUNS, having planets revolving round them in the immensity of space; and it has been observed, that there are stars of all the colours of the spectrum. The stars are usually discovered by the eye from planets by their twinkling, which arises, probably, from some unequal refraction of light, in consequence of the distance of its path. There are stars seen now in the heavens which did not appear formerly, and many have disappeared, which are recorded as shining with brilliancy in former ages. Some stars appear and disappear alternately; of others the magnitude and brilliancy are variable.

When we come, therefore, to consider the vast distance of the fixed stars with the progressive, though rapid, motion of light, it is quite clear that many stars which *now* appear shining, may have been annihilated long ago, and that the last beams which they shed may take years in reaching this earth. If our Sun were suddenly extinguished, we should not know it until eight minutes after the extinction; and if it were suddenly rekindled, its rays would take eight minutes in order to reach us.

> How distant some of the nocturnal suns!
> So distant, says the sage, 'twere not absurd
> To doubt, if beams, set out at Nature's birth,
> Are yet arrived at this our foreign world;
> Yet nothing half so rapid as their flight.—YOUNG.

In order to acquire a knowledge of the aspect of the heavens, it is necessary for those who live in the northern hemisphere to direct their attention to the *polar star*. This is one of the chief stars of the constellation termed the *Little Bear*, (see fig. 47,) and is of the second magnitude. It is about 1½° from the pole; and, saving the small circle which it thus describes, it is always in the same position at every hour of the day and night, and at every season of the year. To the point, from which this star is about 1½° distant, there is, southward, a corresponding point, round which *two* points the concave sphere of the heavens, studded with stars, seems to turn; this being, in reality, due to the diurnal motion of the earth on its axis. The stars round about these two points are called *circumpolar* stars, as revolving constantly about the poles; and those which, in consequence, never set to our and more northern latitudes, are

termed stars of *perpetual apparition*, because they are constantly above the horizon. The stars *α* and *β*, in the Great Bear are called the *Pointers*, because, if we follow them, they lead almost in a right line to the Pole-Star:—they serve, therefore, to *point out* this star. After the Great and Little Bears, which are very conspicuous, and easy to remember, the other principal constellations may be readily recognised. Nearly surrounding the Little Bear is the constellation Draco. In the upper corner of the right hand, appear parts of the constellations Lynx and Camelopardalus; and at the lower corner of the left hand, part of the constellation Boötes.

The constellation Orion, the Pleiades, and the star Arcturus, of the first magnitude, are known in Scripture. The term *Mazzaroth*, used in the book of Job, xxxviii. 32, is supposed to imply the *constellations of the Zodiac*, which are thought to be meant by Joseph, when he spoke of the sun, moon, and eleven stars, bowing down to pay him homage, himself being the twelfth.—Gen. xxxvii. 9. But the science of astronomy was not much encouraged at any time among the Jewish people, lest they might the more easily be allured to join in the idolatries of the neighbouring nations, all of whom eagerly gave themselves up to the worship of the "heavenly host."

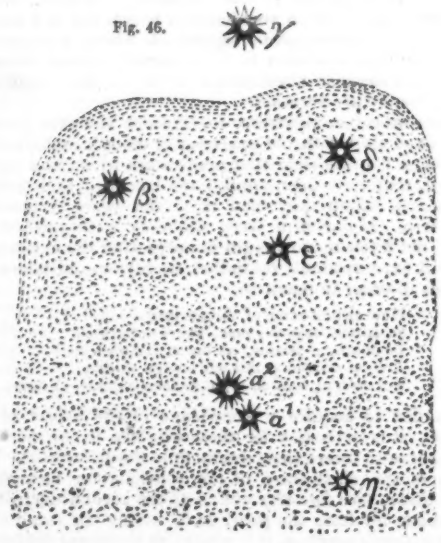
We ought not to omit to mention, that in the Southern Hemisphere is the constellation called the CROSS, which, from the disposition of the principal stars, is a type of that sacred emblem; it is almost entirely enveloped by the southern part of the milky way, as shown in the figure. This is, perhaps, one of the justest configurations that astronomers have ever made, and is thus alluded to by the poet Rogers, who also speaks of the superior radiance of the stars in the heavens below the line:—

> ..... And now in opener skies
> Stars yet unnamed of purer radiance rise!
> Stars, milder suns, that love a shade to cast,
> And on the bright wave fling the trembling mast!
> Another firmament! the orbs that roll,
> Singly or clustering, round the southern pole!
> Nor yet the four that glorify the night—
> Ah, how forget, when to my ravished sight
> The CROSS shone forth in everlasting light!

The mariners in the *Lusiad* also thus apostrophize this constellation:—

> While nightly thus the lonely seas we brave,
> Another Pole-star rises o'er the wave;
> Full to the south a shining CROSS appears;
> Our heaving breasts the blissful omen cheers.
> Seven radiant stars compose the hallowed sign,
> That rose still higher o'er the wavy brine.

Fig. 46.



Owing to the annual motion of the Earth, the Sun appears to move among the zodiacal constellations from West to East. Hence it is that, while the whole dome of the fixed stars seems to move round the earth from East to West, in consequence of the Earth's diurnal motion, the stars appear to rise about 3′ 56″ sooner every evening, and thus seem to gain nearly one whole revolution over the Sun in a twelvemonth, which is due to the Sun having finished its circular course through the ecliptic. The Earth completes one revolution on its axis in twenty-three hours and fifty-six minutes, which is termed a *sidereal* day, being the time which elapses from any star coming upon the meridian till its arriving there again; this would, therefore, be the length of the day, were the Earth stationary; but, as we said before in other words, the Earth advances nearly one degree in its orbit in one day, or the Sun seems to move this space in the ecliptic.

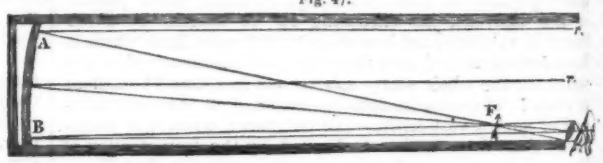
When the Moon, in her passage round the Earth, passes over any of the fixed stars or planets, she is said to *occult*, or *hide* them; and such a phenomenon is termed an *occultation*, an observation of which is useful in determining longitude.

One of the latest opinions respecting the cause of *shooting stars* is, that they are fragments of planets, which, in the course of their revolutions, come, at certain times, within visible range of the earth.

Having had occasion, more than once, to refer to the discoveries made by Sir William Herschel, in the celestial regions, we cannot altogether dismiss the subject, without describing the stupendous and wonderful instrument, which he himself constructed, and with which he enriched the modern state of astronomical knowledge. The magnifying powers of this instrument exceeded all that had ever been known, previously or since.

We will suppose the reader to be at least moderately acquainted with the principles and use of the common refracting telescope: he will therefore observe that the subjoined figure affords a representation of Herschel's REFLECTING Telescope:—

Fig. 47.



Let us suppose AB to be a concave reflector, and *r*A, *r*B to be rays proceeding from a distant object, such as a star. The reflector AB is not placed symmetrically across the tube, but has such a degree of inclination given to it, as will bring the rays to a focus at F, near the margin of the mouth of the tube. The eye of the observer being now placed at that point, he will see the image formed by the focalization of the rays. The object to be obtained in thus bringing the rays to a focus at the margin of the tube, instead of at the centre of its diameter, is, that the body and head of the observer may intercept as few rays as possible; for it will be seen that it is quite impossible for him to look into the tube, without obstructing the passage of some of the light proceeding from the object. But this obstruction is thus limited as much as possible.

This telescope was begun by Sir William in the year 1785, by the pecuniary aid afforded to him by King George the Third, who was his patron. Herschel superintended the whole of the construction of it himself; and he had as many as forty workmen employed upon it at once. In February, 1787, he had the first view through this telescope, although it was not completely finished till August, 1789.

The great reflector AB was forty-eight inches in diameter of polished surface. A speaking trumpet was fitted to the side of the telescope, for the observer to communicate the result of his observations to an assistant below, who was stationed in a small house, and provided with various instruments for measuring time, the positions of the stars, &c. This vast tube was moved about in any direction, by means of a large and complicated apparatus. The eye-pieces, through which the observer viewed the reflected image of an object, were held at the mouth of the tube by a sliding apparatus, by which the attention could be directed to any particular part of the speculum AB.

The frame-work of this instrument having been found to be greatly decayed, after it had remained thirty years in its place, the whole was taken down and replaced by a smaller one on the like construction by Herschel's son, one of the most distinguished astronomers of modern days.

No sooner had the great telescope been erected by Sir W. Herschel, than he began an important series of discoveries by its means. He discovered the sixth satellite of Saturn (five only having been previously known,) on the day

that this instrument was completed. He had already discovered the planet Uranus, as we related in our last paper; a circumstance, such as had never taken place since the days of the most ancient nations of the world. Moreover, by the aid of the new telescope, Herschel distinguished, one by one, six luminaries revolving about it; as also the seventh satellite of Saturn. The same able astronomer also discovered that the ring which surrounds the planet Saturn, is not only divided into concentric belts by a dark circle, as had been already noticed by Cassini, but that the ring likewise revolved about the body of the planet.

The art of constructing telescopes, has, like all other arts, advanced by degrees to its present state of comparative perfection. In the case of the reflecting telescope, which is, for astronomical purposes, a vast and efficacious improvement upon the former mode of using these instruments, there have been several sorts at different times constructed. These go by the names of the Newtonian, the Gregorian, the Cassegrainian, Brewster's, and Herschel's. The principle of them all is the same: but the circumstances, in which they differ from one another, are chiefly in the manner in which the image of an object is conveyed to the eye of an observer. In every instance, rays of light from the celestial body, pass into the tube of the telescope which is *open* at the end *nearest* to the object, and fall upon the surface of the speculum at the bottom of the tube, as shown in the preceding figure. These rays, after reflection from the surface of the speculum, meet again in a focus near the upper end of the tube, and there form a small image of the object; which image is conveyed to the eye of the observer by one of the five different contrivances, which thus form the points of difference between the various reflecting telescopes.

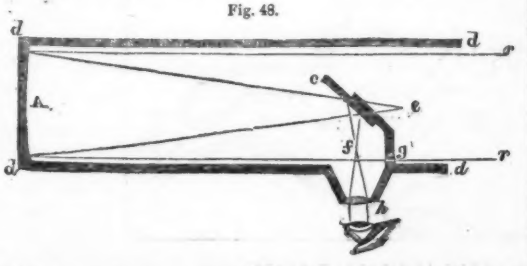
Of Herschel's telescope we have already spoken. Into the merits of the telescopes of Gregory, Cassegrain, and Brewster, it is not necessary here to enter: but we cannot refrain from giving a few brief notices of Newton's genius as developed in the construction of a reflecting telescope, for exploring those celestial tracts, which his skill and perspicacity were employed in reducing to order and harmony, for the better understanding of those who were to come after him.

It has been well remarked of Sir Isaac Newton, that it was his brilliant fortune to improve almost every subject to which he directed his gigantic mind. He was the first to put in practice the idea of employing reflected light for the formation of the image in a telescope. Vast and splendid as were the theoretical and mathematical powers of his mind, yet he did not disdain to construct with his own hands the instrument which his inductive reasoning told him would serve the purpose of a telescope. He, accordingly, made the first reflecting telescope which the world ever saw, and which is now in the museum of the Royal Society of London:—a precious memento of the ingenuity of one whose name will never die.

We are told that Newton's first reflecting telescope was 6¼ inches long, and had an aperture of about 1¼ inches. The eye-glass was inserted in the side of the tube, and was one-sixth of an inch deep. This instrument, although so small, magnified thirty-five times, and enabled Newton to see the crescent-form of Venus, and Jupiter's satellites. He then made another, which was 2½ inches in diameter, and therefore gave a larger reflecting surface to the speculum at the bottom of the tube.

The following figure shows the construction of the Newtonian reflecting telescope.

Fig. 48.



A is the speculum, or reflecting surface, formed of polished metal, either spherically or parabolically curved:—the latter is more correct, but the former is more easy to construct. This speculum, as we saw in the case of Herschel's telescope, is placed at the end of the tube *d d d d*, and has such a degree of curvature, that the rays *r d*, *r d*, from any celestial object, will, after reflection, be conveyed to a focus at *e*, near the mouth of the tube. But, before they reach this point, their progress is arrested by a plane mirror, *c*, so placed as to make an angle of 45° both with the length and with the diameter of the tube. This plane mirror is held in its place by an arm or bracket, *g*, fitted to the side of the tube, but at the same time capable of sliding along it, in order that the distance between the two reflectors may be increased or diminished at pleasure. Let us now suppose that rays from a celestial object are entering the tube, and that they are reflected from the surface of the speculum A: instead of meeting at *e*, they are reflected a second time, from the small plane mirror *c*, and cross each other at the point *f*, at which point of intersection an image of the object is formed. At this point of the process is the following adaptation:—a convex lens is fitted into a socket *h*, the focal power of which lens is such, that the image is in that focus, and the magnitude of the image is increased.

Many disadvantages resulted from the necessity of the observer looking in at the *side* of the tube; and inconvenience manifestly results from looking down the mouth of the tube. Those who have attempted to construct reflecting telescopes, have always had in view the removal or diminution of the difficulties mentioned before. Complete success, without loss of light, has not, however, attended their efforts.

From the time when Galileo made his telescope, which was of the common refracting sort, with eye-pieces, one at each end of a tube, to the construction of Herschel's great reflecting telescope, a period of nearly 200 years, the knowledge of the heavens rapidly progressed. The construction of the Newtonian telescope was an event mid-way; but the further extent of our knowledge of "the argent fields above," will have to depend mainly on the further improvement of our telescopes.

In concluding the subject of ASTRONOMY, we cannot do better than use the thoughtful and eloquent words of Chalmers:—

"The first thing which strikes a scientific observer of the fixed stars, is their immeasurable distance. If the whole planetary system were lighted up into a globe of fire, it would exceed, by many millions of times, the magnitude of this world, and yet only appear a small lucid point from the nearest of them. If a body were projected from the sun, with the velocity of a cannon-ball, it would take hundreds of thousands of years before it described that mighty interval which separates the nearest of the fixed stars from our sun and from our system. If this earth, which moves at more than the inconceivable velocity of a million and a half miles a day, were to be hurried from its orbit, and to take the same rapid flight over this immense tract, it would not have arrived at the termination of its journey after taking all the time which has elapsed since the creation of the world. These are great numbers, and great calculations; and the mind feels its own impotency in attempting to grasp them. We can state them in words. We can exhibit them in figures. We can demonstrate them by the powers of a most rigid and infallible geometry. But, no human fancy can summon up a lively or an adequate conception—can roam in its ideal flight over this immeasurable largeness—can take in this mighty space in all its grandeur, and in all its immensity—can sweep the outer boundaries of such a creation—or lift itself up to the majesty of that great and invisible arm on which all is suspended.

"But what can those stars be which are seated so far beyond the limits of our planetary system! They must be masses of immense magnitude, or they could not be seen at the distance of place which they occupy. The light which they give must proceed from themselves; for the feeble reflection of light from some other quarter, would not carry through such mighty tracts to the eye of an observer. A body may be visible in two ways. It may be visible from its own light, as the flame of a candle, or the brightness of a fire, or the brilliancy of yonder glorious sun, which lightens all below, and is the lamp of the world. Or it may be visible from the light which falls upon it, as the body which receives its light from a taper, or the whole assemblage of objects on the surface of the earth, which appear only when the light of day rests upon them—or the moon, which, in that part of it that is towards the sun, gives out a silvery whiteness to the eye of the observer, while the other part forms a black and invisible space in the firmament—or as the planets, which shine only because the sun shines upon them; and which, each of them, present the appearance of a dark spot on the side that is turned away from it. Now

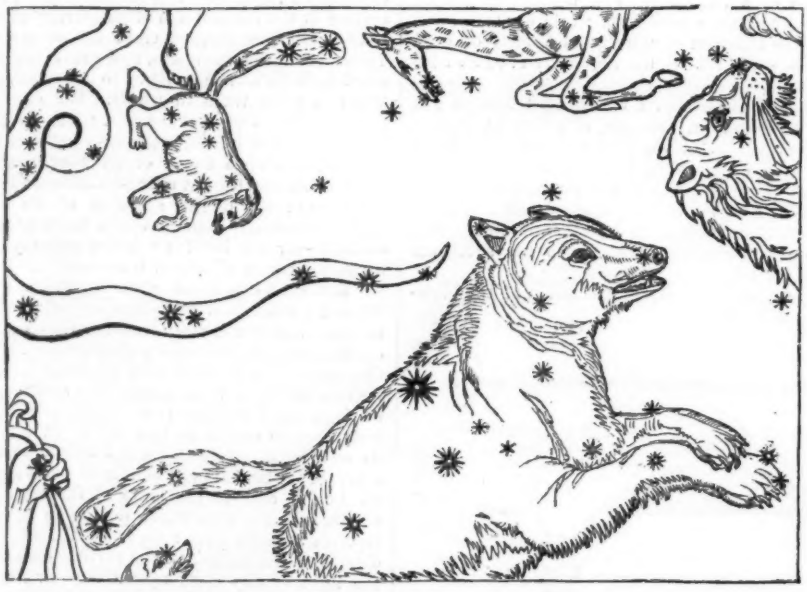
apply this question to the fixed stars. Are they luminous of themselves, or do they derive their light from the sun, like the bodies of our planetary system? Think of their immense distance, and the solution of this question becomes evident. The sun, like any other body, must dwindle into a less apparent magnitude as you retire from it. At the prodigious distance even of the very nearest of the fixed stars, it must have shrunk into a small indivisible point. In short, it must have become a star itself, and could shed no more light than a single individual of those glimmering myriads, the whole assemblage of which cannot dissipate, and can scarcely alleviate, the midnight darkness of our world. These stars are visible, not because the sun shines upon them, but because they shine of themselves, because they are so many luminous bodies scattered over the tracts of immensity; in a word, because they are so many suns, each throned in centre of his own dominions, and pouring a flood of light over his own portion of these unlimitable regions.

"At such an immense distance for observation, it is not to be supposed that we can collect many points of resemblance between the fixed stars and the solar star, which forms the centre of our planetary system. There is one point of resemblance, however, which has not escaped the penetration of our astronomers. We know that our sun turns round upon himself in a regular period of time. We also know that there are dark spots scattered over his surface, which, though invisible to the naked eye, are perfectly noticeable by our instruments. If these spots existed in greater quantity upon one side than upon another, it would have the general effect of making that side darker; and the revolution of the sun must, in such a case, give us a brighter and a fainter side, by regular alternations. Now, there are some of the fixed stars which present this appearance. They present us with periodical variations of light. From the splendour of a star of the first or second magnitude, they fade away into some of the inferior magnitudes; and one, by becoming invisible, might give reason to apprehend that we had lost him altogether; but we can still recognise him by the telescope, till at length he reappears in his own place, and, after a regular lapse of so many days and hours, recovers his original brightness. Now, the fair inference from this is, that the fixed stars, as they resemble our sun, in being so many luminous masses, of immense magnitude, they resemble him in this also, that each of them turns round upon his own axis; so that, if any of them should have an inequality in the brightness of their sides, this revolution is rendered evident, by the regular variations in the degree of light which it undergoes.

"Shall we say, then, of these vast luminaries, that they were created in vain? Were they called into existence for no other purpose than to throw a tide of useless splendour over the solitudes of immensity? Our sun is only one of those luminaries, and we know that he has worlds in his train. Why should we strip the rest of this princely attendance? Why may not each of them be the centre of his own system, and give light to his own worlds? It is true that we see them not; but could the eye of man take its flight into those distant regions, it would lose sight of our little world before it reached the outer limits of our system—the greater planets would disappear in their turn—before it had described a small portion of that abyss which separates us from the fixed stars, the sun would decline into a little spot, and all its splendid retinue of worlds be lost in the obscurity of distance—he would at last shrink into a small indivisible atom, and all that could be seen of this magnificent system, would be reduced to the glimmering of a little star. Why resist any longer the grand and interesting conclusion? Each of these stars may be the token of a system as vast and as splendid as the one which we inhabit. Worlds roll in these distant regions; and these worlds must be the mansions of life and of intelligence. In yon gilded canopy of heaven, we see the broad aspect of the universe, where each shining point presents us with a sun, and each sun with a system of worlds—where the Divinity reigns in all the grandeur of His attributes—where He peoples immensity with His wonders; and travels in the greatness of His strength through the dominions of one vast and unlimited monarchy.

"The contemplation has no limits. If we ask the number of suns and of systems, the unassisted eye of man can take in a thousand, and the best telescope which the genius of man has constructed, can take in eighty millions. But why subject the dominions of the universe to the eye of man, or to the powers of his genius? Fancy may take its flight far beyond the ken of eye or of telescope. It may expatiate in the outer regions of all that is visible—and shall we have the boldness to say, that there is nothing there?—that the wonders of the Almighty are at an end, because we can no longer trace His footsteps?—that His omnipotence is exhausted because human art can no longer follow him?—that the creative energy of God has sunk into repose, because the imagination is enfeebled by the magnitude of its efforts, and can keep no longer on the wing through those mighty tracts, which shoot far beyond what eye hath seen, or the heart of man hath conceived: which sweep endlessly along, and merge into an awful and mysterious infinity.

Fig 49.



THE CONSTELLATION OF THE GREAT AND LITTLE BEARS.

LONDON: Published by JOHN WILLIAM PARKER, West Strand; and sold by all Booksellers.